Minutes of the Aura Science Team Meeting, April 9-11, 2002

The annual Aura science team meeting was hosted by KNMI in Woudshoten, the Netherlands and chaired by chaired by Anne Douglass and the principal investigators of the four instruments on the Aura platform. Each of the Aura working groups met on Tuesday April 9. The principal accomplishments of the working groups were summarized in plenary sessions on Wednesday and Thursday.

Participants were welcomed on Wednesday morning by Gerbrand Komen, the head of the Climate Research and Seismology department at KNMI. (KNMI has been collecting climate data since 1854!) Mark Schoeberl, Aura Project Scientist, followed and spoke of our need to engage the larger atmospheric chemistry community before launch. Mike Kurylo, NASA headquarters OMI program scientist, spoke of the importance of Aura data to resolve the current debate on chemistry-climate coupling. The new Aura Project Manager, Rick Pickering, was introduced; he reported that spacecraft integration is proceeding well. His background with the Aqua project makes it likely that Aura platform integration will profit as fully as possible from the Aqua experience. The principal challenges facing the Aura community are meeting the instrument delivery schedule to maintain the launch schedule and staying within the present budget. All instruments should be delivered by the end of the year.

A principal outcome of this meeting is recognition that the Aura science community must make tangible contributions to the global observing strategy as explained in the validation working group report (below). To that end, the validation working group meeting planned for September 17-18 will be combined with a science team meeting. The other working groups may choose to meet on Monday, September 16. This meeting will include representatives from the ground based, aircraft, and balloon measurement community. The goal will be to articulate the science contributions that can be expected from the global data, and to integrate these in the science plans for the correlative observations campaigns. The Aura science team meetings are expected to take place twice per year for the foreseeable future.

The global observing strategy document is being coordinated by Jim Anderson. The present version of the document is available from the Harvard ftp site ftp.arp.harvard.edu/pub/AURA or by request from the Aura Project Scientist or his Deputies. Input to the next version should be made by August 1, so that the draft can be updated and circulated before the September validation/science meeting.

A monthly telecon is planned to improve communications between the project science office and the principal investigators. It was agreed that the dates of all science team meetings for each instrument will now be included on the Aura website (http://eos-aura.gsfc.nasa.gov).

Instrument Reports

Pieternel Levelt reported on progress for OMI since the November 2001 meeting. The flight hardware is ready; a plan for calibration should be completed by the end of April. This plan will be based on a combination of ambient and vacuum calibration measurements. This calibration is a compromise between the scientists and industry and will represent the absolute minimum calibration needed for flying the OMI-instrument. OMI has validation needs that are not all met within current validation plans; OMI requires high spatial resolution measurements, and also observations of tropospheric profiles and columns of NO2 and ozone under both polluted and clean conditions.

Reinhard Beer reported on the TES instrument. TES is near completion, but progress is frustratingly slow as it is necessary to align the beam splitter before proceeding with calibration. The thermal vacuum cycles necessary to test alignment after adjustment each require about a week; TES has just completed cycle 17, and requires at least one more cycle to bring the alignment up to specification.

Joe Waters reported that MLS performance will meet all requirements after a few identified fixes, and that instrument integration is nearly complete. Calibration procedures have been demonstrated. Their largest concern is the threat to calibration caused by time constraints. They have prioritized their products for calibration. There are possible trade offs between resolution and precision to achieve higher vertical resolution in the lower stratosphere. These are still being considered. A second concern to the MLS success is the threat to the budgets for algorithm development and science.

John Gille reported on the development of HIRDLS. There is a nagging problem with the IPU, which resets intermittently (about once in 24 hours). This should be solved before sending the instrument from Lockheed Martin in California (where the instrument is being built) to Oxford England for calibration. John Barnett reported on the calibration plans for HIRDLS that have been made in Oxford using the HIRDLS engineering model. The spatial, spectral, and radiometric calibration must be completed before the instrument is delivered for integration on the spacecraft.

Working Group Reports

Nathaniel Livesey reported for the **Algorithm Working Group**. The principal accomplishment was completion of the first phase of an algorithm intercomparison project. This project uses output from the MOZAIC model provided by Doug Kinnison; constituent profiles for an orbit through the model are used to calculate radiances; the instrument algorithms are used to retrieve vertical distributions of ozone, temperature and water vapor from this pseudo data set. This exercise assumes that each instrument sees the same air mass. Although this will not be true in practice, comparisons of this sort will allow the algorithm teams to understand how to intercompare the results for constituents such as ozone that are measured by all the Aura instruments. For example, the differences in resolution were apparent when comparing the high resolution retrieved ozone from HIRDLS with lower resolution MLS and even lower resolution for ozone profiles retrieved from TES nadir observations. However, the retrieved profiles compared favorably with the original model profiles when the instrument precision, accuracy and resolution are taken into account. A written report of this exercise will be posted on the Aura website under the algorithm working group. Note that this intercomparison exercise was completed before the working group meeting. At that meeting, each instrument reported on the status of their algorithms. The next step in the algorithm intercomparison is to include OMI ozone profiles and also to include more constituents.

The **Validation Working Group**, co-chaired by Lucien Froidevaux and Anne Douglass, has held meetings involving the aircraft, balloon, and ground based measurement community in November, 2001, January, 2002, and March, 2002. This group will contribute to a global observing strategy that will reflect measurement needs for the next several years. This strategy will also fulfill the following three purposes: 1) to explain how measurements from all platforms will be used to address science questions posed in the NASA strategic plan; 2) to show how the balloon, aircraft, and ground based measurements will be used to provide information needed for validation of Aura data (these needs and preliminary plans are described in the Aura Science Data Validation Plan, Version 1.o, July 12, 2001); 3) to develop a future NRA for Aura validation measurements and science. At the Tuesday meeting, the principal focus was on developing implementation plans for acquiring and distributing data that are collected worldwide regardless of a specific campaign. Persons were identified to work with the groups responsible for making measurements. For temperature these include the Network for Detection of Stratospheric Change (NDSC), radiosondes, the GSFC Data Assimilation Office analyses, , and the National Center for Environmental Prediciton

(NCEP) analyses. For ozone these include the ozonesonde network, the Measurement of Ozone and water vapor by AIrbus in-service aircraft (MOZAIC) program, the Stratospheric Aerosol and Gas Experiment (SAGE) platform, the Sciamachy and GOMOS instruments on Envisat, NDSC, and ozone column observations. For water vapor, these include NDSC, the DOE Atmospheric Radiation Measurement (ARM) Program, and MOZAIC. It is particularly important to set up contacts and data protocols well before launch because coincidence requirements will make it necessary to some make measurements on particular days and times. To facilitate coincident measurements, software that determines when coincidences occur for specific locations will be developed at GSFC. The Data Systems Working Group may interact with the Validation working group to develop the archive for this correlative data, and to resolve any issues connected with format and exchange. The archived data should be in a common format; this will probably make it necessary that the project develop software to convert observations that may be reported in various formats to HDF-EOS. Some measurements needed for their retrievals rather than specifically for correlative information were reported; these include ir surface emissivity, needed for TES nadir retrievals, and cloud particle size distributions needed for MLS retrievals of ice water content. Spectroscopic laboratory data is also needed by several instruments; however, such work is already underway and should meet the primary platform needs.

Ernest Hilsenrath presented the report of the **Education and Outreach working group**. One important concern, that was the focus on much discussion, is how to inform government, industry and the public on how Aura research benefits the community/society. Progress was reported on five principal activities. The American Chemical Society ChemMatters magazine reaches thirty thousand of high school teachers throughout the United States. An insert introducing the Aura mission to high school students was published in 2000; an issue on Aura science was published in September 2001; an issue on Aura technology and some of the people who contribute to the project is planned for September 2002. This group is working with PIs in the GLOBE program to involve students and their teachers in making measurements of aerosols, UV-A, and surface ozone that can be used with Aura measurements. KNMI will host a GLOBE student science conference in June; a GLOBE aerosols and UV-A teacher/scientist workshop will take place at GSFC in July. These will help to involve and motivate the students and their teachers to ensure sustained high quality measurements. Atmospheric chemistry and Aura will be the focus of the second Global Links exhibit in the Forces of Change exhibition at the Smithsonian. The Aura brochure is being planned for release about six months prior to launch. All instrument teams were asked to provide material for the brochure. The Earth Observatory web site includes articles on atmospheric chemistry

written for the public by a member of the EPO team. The Aura web site provides information that is of interest to scientists, engineers and the public.

Scott Lewicki reported on the **Data Systems Working group**. This group has agreed upon guidelines for HDF-EOS Aura File Format. They are attempting to carry their initial agreement further, by expanding the mandatory attribute list, agreeing on standardized scaling definitions, and agreeing on file naming conventions. They have made progress on development of standard level 3 (gridded) products, and also a way to implement HDF-EOS5 for zonal mean information. A concern is that the Interactive Data Language (IDL) does not currently support HDF-EOS5, although a release with this capability is expected in about a year.

Angie Kelly reported on the activities of the **Mission Operations Working Group** (MOWG). The April 9 meeting focused on spacecraft and simulated data collection for ground system testing needs. The importance of collecting appropriate data sets during integration and test (I&T) activities at TRW was addressed. The instrument teams were asked to work diligently with their I&T counterparts to ensure that the activity plans and procedures reflect the collection of specific data sets for their science processing systems. One-on-one testing splinter sessions were also conducted with each of the teams to determine what simulated data is necessary to complement the spacecraft I&T data to conduct multi Day-In-The-Life (DITL) ETE Mission Operations and Science System (MOSS) tests from the ground stations through Level 1+production at the SIPS.

Concurrent with the science team meeting, operations working meetings with the OMIS operations team was held on April 8-12 in Leiden. The meetings resulted in a good exchange of technical information between GSFC, Northrop, KNMI, and FokkerSpace personnel. Splinter sessions on the OMI direct broadcast (DB) station and the rate buffered data requirements were also held. Finnish Meteorological Institute (FMI) personnel provided information on their plan to build the DB station in Sodankyla, Finland, which they hope will be operational next year. A full meeting of this group is planned at GSFC four months after Aqua launch to make the best use of lessons learned from the Aqua experience. Mission operations review and a full ground station review are expected in January 2003.

The **Aerosol Working Group**, chair by Steve Massie, also met on Tuesday. There were updates from members of the four instrument groups. The primary points made by the teams with regard to aerosols were given for each instrument**.** OMI: The

presentation was based upon material presented at the successful OMI ATBD review. Near term effort will focus on the effects of nonspherical particle shape upon the optical properties of the tropospheric aerosol. TES: Aerosol effects for both nadir and limb viewing geometry are currently being examined. The TES team is considering inserting clouds into the retrieval algorithm as an additional species. MLS: The retrieval code is being exercised to derive ice water content from a field of variable cloudiness. A climatology of ice crystal size (the particle size distribution) as a function of the ambient temperature is needed. HIRDLS: In response to the AURA Validation meeting in Pasadena several weeks ago, the HIRDLS presentation focused upon a suggested study in which HIRDLS data is used to study tenuous cirrus and H_2O near the tropopause. The proposed study illustrates how AURA data can be used to study the processes that couple H_2O dehydration, dynamical waves, and cirrus in the tropopause region.

Science Presentations

Craig Long presented results for assimilation of SBUV profiles of ozone and showed that ozone forecasts from the assimilation are much better than forecasts based on persistence or on statistical regression.

Robert Voors identified potential users for O3 profiles from OMI; these include those interested in developing a tropospheric ozone product, ozone assimilation, the total ozone column and those interested in SO2 retrieval. The profiles may improve the total ozone column retrieval in the case that the actual profile shape differs significantly from the ozone climatological profile.

Henk Eskes reported on GOME ozone data assimilation and ozone forecasts. These results are similar to those reported by Long. In a case study, the uv reaching the surface equatorward of the Antarctic circle was forecast to be comparable to that reaching the surface at the equator for a large fragment of the ozone hole.

Paul Fortuin presented observations of ozone, wind, and temperature for the Paramaribo station at 5.8N. This station is in the middle of the annual migration range of the intertropical convergence zone, and the measurements show this migration as air comes from different regions at different times of year. Appearance of layers with different compositions is common in this part of the tropics. Effects of the monsoon were apparent.

Folkert Boersma presented NO2 column density retrievals with OMI. Tests on GOME NO2 fields showed the potential to determine the stratospheric NO2 column by applying a wave 2 Fourier filtering technique. This technique rejects 'fast' variations in the field that are attributed to the troposphere. The difficulties in retrieving the tropospheric column were illuminated. Knowledge of the thickness of the boundary layer and the surface albedo are both required. The sensitivity of the air mass factor to the boundary layer increases with solar zenith angle.

On Thursday morning, Ankie Piters gave plans for quality assurance for SCIAMACHY validation. SCIAMACHY has 45 products, and a planned five year lifetime. There are 85 ground stations and 14 balloon and aircraft campaigns to provide validation information. A single person is responsible for coordinating presentation of validation for each constituent.

Ellen Brinksma presented plans to obtain correlative information for the OMI measurements that are not already part of the Aura platform validation plans. OMI validation will have both European and American partners. European Union Funding will be sought for flying the AMAX DOAS airplane instrument (property of the Universities of Heidelberg and Bremen), which can provide stratospheric and tropospheric columns of ozone and NO2, as well as measurements of other trace gases useful for OMI validation. Ellen pointed out that there is a need for a mobile ground station, which will be able to measure in polluted environments. The OMI validation handbook should be completed this year.

Paul Palmer showed how GOME columns of HCHO may be used to derive emissions of nonmethane hydrocarbons. Methane, methanol, and isoprene all contribute to HCHO production; the first two have much longer lifetimes than isoprene. He also showed how higher surface temperature are linked to HCHO column amounts, mainly through the enhanced emission of isoprene.

Randall Martin showed compared tropospheric ozone columns derived from TOMS with those calculated using the Harvard model to show areas of agreement and disagreement. Where the model disagrees most with TOMS it is in reasonable agreement with measurements from MOZAIC. It is not possible at present to resolve these differences. He has recently focused on improving the way to calculate the air mass factor for derivation of NO2 columns, as this term dominates the error during the summer.

Bill Randel used HALOE measurements of water, methane, and ozone and model results to investigate the effect of the monsoon on stratospheric troposphere exchange. There are features in the observations that are symmetric with respect to longitude and provide a means of testing the realism on model transport associated with the regional of active strat/trop exchange associated with the monsoons.

Steven Pawson provided an overview of the DAO products and ongoing research. A constituent data assimilation working group already exists, and Aura participation is expected in the coming months given the from interest the science teams in using data assimilation either to improve retrievals or to produce a consistent global data set.

In the afternoon, Johan de Haan addressed questions concerning the effects of rotational Raman scattering on the total ozone retrieval. These effects are included in the TOMS retrievals, and may contribute to the systematic difference between TOMS and DOAS ozone.

Byron Boville reported on progress with the Whole Atmosphere Community Climate Model (WACCM). A semi-annual oscillation that exhibits may observed features may be produced in the mesosphere using several different forcings. This is being traced to the convective paramaterization, that in general does not exhibit spectral frequency or wave spectrum that has been derived from observations.

Juan Acarreta discussed factors affecting the derivation of the cloud top height from OMI observations using O_2-O_2 absorption. Ozone absorption in the fit window was shown to be an important factor to include.

Mark Schoeberl showed results from age spectrum calculations made with a trajectory model using various sets of assimilated data and also output from a general circulation model. The transport characteristics of the assimilations in the tropics were shown to produce rapid vertical and horizontal mixing; the resulting age in the tropics appeared appropriate compared with observations, but at high latitude the age was much too old.

Anne Douglass compared constituent fields calculated using a CTM forced by a data assimilation system with those calculated using a CTM forced by data from the GCM. The same GCM is used in the assimilation process. Comparisons of NOY/O3 and ozone profiles with observations from the ER-2 and ozone sondes show that the assimilation process corrupts the observed isolation of the tropics.

Several poster papers were also presented at this meeting.

Bill Read described the methodology and validation of upper tropospheric humidity measurements by the Upper Atmosphere Research Satellite (UARS) Microwave Limb Sounder. The measurements in cirrus are compared with UARS Cryogenic Limb Array Etalon Spectrometer (CLAES) extinction measurements and and MLS cirrus detection algorithm. CLAES identification of cirrus from 316 to 147 hPa correspond well with MLS humidity greater than 100%.

Hugh Pumphrey showed that two instruments, TIMED/SABER and Aura/MLS will make improved measurements of mesospheric and lower thermospheric ozone. The measurements will show the nighttime ozone, and its seasonal and diurnal cycles.

Lucien Froidevaux used version 5 ozone data from UARS MLS and total column data from the TOMS instrument to estimate the tropospheric ozone residual. Maps for 2 week averages are compared with maps from results for tropospheric ozone as derived from TOMS data by Thompson and Hudson. Similar salient spatial and seasonal variations are observed in both datasets.

Alyn Lambert presented the retrieval methods being developed for the HIRDLS instrument, and a detailed discussion of the characterization of the error sources for the HIRDLS instrument.

Ernest Hilsenrath presented a new ground measurement program, Skyrad, that uses the SSBUV calibration facilities at GSFC and radiative transfer codes used for the TOMS and SBUV/2 algorithms. The Skyrad instruments will be calibrated and maintained to a precision of a few tenths of a percent. Skyrad data will be used to provide long term calibration and performance monitoring of present and upcoming backscatter satellite instruments (SBUV, TOMS, GOME, SCIAMACHY, and OMI).

Kevin Bowman showed work characterizing a tomographic retrieval from a simulated limb measurement of the Tropospheric Emission Spectrometer (TES). The GEOS chemical transport model is used to create an example ensemble of vertical profiles separated by fixed angular distances. Rays are traced through this ensemble to the TES sensor. The method is used to characterize a TES limb retrieval of a simulated plume of gas.